DOCUMENT RESUME

ED 390 671 SE 057 298

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| AUTHOR | Roeder, John L. |
| TITLE | States Parallel National Standards with Frameworks. |
| PUB DATE | 94 |
| NOTE | 8p. |
| PUB TYPE | Journal Articles (080) |
| JOURNAL CIT | Teachers Clearinghouse for Science and Society Education Newsletter; v13 n3 p19-23,25 Fall 1994 |
| EDRS PRICE | MF01/PC01 Plus Postage. |
| DESCRIPTORS | Educational Change; Elementary Secondary Education; Science and Society; *Science Curriculum; Science Education; State Curriculum Guides; *State Standards; Technology |
| IDENTIFIERS | National Science Education Standards; *National Standards; Reform Efforts |

ABSTRACT

While the National Research Council spearheads the development of science education standards at the national level, many states have been operating on parallel tracks and have developed state curriculum frameworks. This article describes the state frameworks from California, Florida, and New York, titled "Science Framework for California Public Schools, Kindergarten Through Grade Twelve", "Science For All Students: The Florida Pre K-12 Science Curriculum Framework", and "Framework for Mathematics, Science, and Technology," respectively. Expectations for science programs and content questions from the California framework, underlying principles and characteristics of the Florida framework, and general principles for learning in the New York framework are listed. The importance of the Science Technology Society (STS) movement in these frameworks is discussed. Information on how to get copies of publish d frameworks is provided. (JRH)

# States Parallel National Standards with Frameworks

by John L. Roeder

TEACHERS CLEARINGHOUSE
FOR SCIENCE AND SOCIETY EDUCATION
NEWSLETTER

Sponsored by the Association of Teachers in Independent Schools

Affiliated with the Triangle Coalition for Science and Technology Education

Vol. XIII, No. 3
Fall 1994

# States parallel national standards with frameworks

by John L. Roeder

Our past several issues have covered the development of science education standards. Or, as Project 2061 calls them, benchmarks. New York state used to call them outcomes. But whatever it's called, it's what students are supposed to know or be able to do at different stages of their lives.

While the National Research Council spearheads the development of science education standards at the national level, many states are operating on parallel tracks. In most cases the result has been called a "framework," which New York state defines as a "stepping stone between standards and curriculum" — a document that "provide(s) direction for local schools and districts to follow as they design curriculum," and which Florida regards as "a map to guide districts and schools as they grapple with science curriculum reform . . . *descriptive*, not prescriptive." Like the *Curriculum Framework* on *Teaching About the History and Nature of Science and Technology*, described in our Fall 1993 issue, these frameworks are characterized by themes and instructional models, the latter often spelled out in a series of principles.

### The Oldest Framework — from California

The oldest state framework I have examined has been that from California. Although the present *Science Framework for California Public Schools, Kindergarten Through Grade Twelve* was published in 1990, its earliest predecessor came out in 1978. The present *California Framework* was drafted, according to Francis Laufenberg, President of the California State Board of Education, "because our conviction that all science should be taught nondogmatically needed clarification and amplification." Laufenberg cites the need for students "to learn and appreciate the distinctions between fact and theory, between belief and dogma" and adds that "Students in today's culture must routinely be reminded that skepticism and understanding are characteristics of a scientifically literate mind."

According to Laufenberg, "Thematic teaching, coupled with active learning, is the best way to provide students with the education they will need as voters, consumers, and parents in the future." According to State Superintendent of Public Instruction Bill Honig, "By active learning we mean instructional activities where students take charge of learning the major ideas in science. . . . The important common denominator for active learning is that students regularly make new associations between new ideas and their previous conceptions of how the world works."

Citing Project 2061's *Science for All Americans*, published only a year earlier, the 1990 *California Framework* "emphasizes a thematic approach to science" to counteract "the general trend . . . to reduce and compartmentalize science content and focus on isolated facts and concepts." A whole chapter is devoted to "The Major Themes of Science." While the themes of Energy, Evolution, Patterns of Change, Scale and Structure, Stability, and Systems and Interactions are developed — the last five taken from *Science for All Americans* and all highlighted in the middle-level curricula described on p. 3 of our Spring 1992 issue — "the particular

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configuration and number of themes is not crucial, [but] the organization of content around thematic lines is." The role of themes in science is likened to that in music and literature, and thematic integration is cited as a learning tool: "If the basic concepts of one field can be transferred by connection or analogy to another field, students will understand that there is a purpose and logic to the system. If curricula and instructors are successful in developing themes for students to use in connecting and integrating science facts, then this intellectual habit will carry over and enrich other fields and disciplines."

On the other hand, "the integration of themes into science curricula does not mean that the usual curricular divisions of physical, earth, and life sciences need be discarded.... Within the individual disciplines, themes need to be instituted and developed throughout a year's study and from one year to another.... Rather than being reorganized around themes, science curricula should be permeated by themes." The "curricular divisions of physical, earth, and life sciences," in fact, form the basis of the California content standards, which are phrased in terms of questions (see box). What students should learn in response to these questions — at levels K-3, 3-6, 6-9, and 9-12 — is written in narrative form from the standpoint of various themes. The narrative is used to stress connections rather than "*factoids* — the isolated facts and definitions that have long dominated science instruction."

In addition to stressing active learning and thematic teaching, the 1990 *California Framework* also advocates many other strategies in vogue today:

•constructivism: "...we have learned that teachers must be cognizant of the conceptions students hold about how things work. And we know that students must create meaning for themselves...."

•enjoyability: "To be effective, science education should be enjoyable." "Enjoyment is a superb motivator of understanding."

•process: "Emphasis should be placed not on coming up with the right answer but on doing science the right way."

•selectivity: "We cannot present the entire body of scientific knowledge because there is too much to teach." "The emphasis on themes in science requires a reconsideration of how much detailed material should be included in science curricula."

•authentic assessment: "Testing and accountability mechanisms must move toward more authentic assessment." "The use of themes . . . encourages . . . connections in review and assessment materials. . . . This is more interesting than the typical chapter review heading 'What Have We Learned?'"

All this and more are encapsulated in ten "expectations — which reflect the main ideas in the framework" (see box). Note particularly that some of these expectations are directed at publishers, who are the intended audience for the final chapter of the *Framework*: "Instructional Materials Criteria." There California portrays itself as one of 22 states conducting state-level review, which it hopes will upgrade published materials.

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### Expectations for Science Programs from the 1990 California *Science Framework*

1. The major themes underlying science, such as energy, evolution, patterns of change, scale and structure, stability, and systems and interactions, are developed and deepened through a thematic approach.

2. The three basic scientific fields of study — physical, earth, and life sciences — are addressed, ideally each year, and the connections among them are developed.

3. The character of science is shown to be open to inquiry and controversy and free of dogmatism; the curriculum promotes student understanding of how we come to know what we know and how we test and revise our thinking.

4. Science is presented in connection with its applications in technology and its implications for society.

5. Science is presented in connection with students' own experiences and interests, frequently using hands-on experiences and interests that are integral to the instructional sequence.

6. Students are given opportunities to construct the important ideas of science, which are then developed in depth, through inquiry and investigation.

7. Instructional strategies and materials allow several levels and pathways of access so that all students can experience both challenge and success.

8. Printed materials are written in an interesting and engaging narrative style; in particular, vocabulary is used to facilitate understanding rather than as an end in itself.

9. Textbooks are not the sole source of the curriculum; everyday materials and laboratory equipment, videotapes and software, and other printed materials such as reference books provide a substantial part of student experience.

10. Assessment programs are aligned with the instructional program in both content and format; student performance and investigation play the same central role in assessment that they do in instruction.

# Content Questions from the 1990 California *Science Framework*

## I. Physical Sciences

A. Matter

1. What is matter, and what are its properties?
2. What are the basic units of matter, and where did matter come from?
3. What principles govern the interactions of matter? How does chemical structure determine the physical properties of matter?

B. Reactions and Interactions

1. What happens when substances change?
2. What controls how substances change?

C. Force and Motion

1. What is motion? What are some basic kinds of motion? How is motion described?
2. What is force? What are the characteristics of forces? What is the relationship of force to motion?
3. What are machines, and what do they do? What principles govern their action?

D. Energy: Sources and Transformations

1. What is energy? What are its characteristics?
2. What do we do with energy: What changes occur as we use it?

E. Energy: Heat

1. What is heat energy? Where does it come from, and what are its properties?
2. How do we use heat energy?

F. Energy: Electricity and Magnetism?

1. What are electricity and magnetism? What are they like, and what are their basic properties? How do they interact?
2. How do we use electricity and magnetism?

G. Energy: Light

1. How does light enable us to see? What are the sources of light? What is light?
2. What are the properties of light?
3. How do we use light?

H. Energy: Sound

1. Where does sound come from?
2. How does sound enable us to hear? How do we produce sounds?
3. How do we use sound?

## II. Earth Sciences

A. Astronomy

1. What kinds of objects does the universe contain, and how do these objects relate to one another?
2. How has the universe evolved?
3. How do we learn about the contents and structure of the universe?

B. Geology and Natural Resources

1. How has plate tectonics shaped evolution of the earth?
2. How are the rocks and minerals formed, how are they distinguished, and how are they classified?
3. What is the history of the earth, and how have geomorphic processes shaped the earth's present features?
4. What are the responsibilities of humans toward natural resources?

C. Oceanography

1. What is the water cycle? How does the water cycle affect the climate, weather, and life of the earth? How does water affect surface features of the land and the ocean floor?
2. What are the oceans? What are the environments and topography of the ocean bottoms? How do the oceans support life, and how have the oceans and their marine life changed through time?
3. How do waters circulate in the ocean, and how does this circulation affect weather and climate?
4. How do humans interact with the oceans? What may be some long-term effects of human interactions with the oceanic environments?

D. Meteorology

1. What are the physical bases of the earth's climate and weather?
2. What are the major phenomena of climate and weather? What are the large- and small-scale causes of climate and weather?
3. How are we affected by weather? How do we predict it? How can we alter it?

## III. Life Sciences

A. Living Things

1. What are the characteristics of living things?
2. How do the structures of living things perform their functions, interact with each other, and contribute to the maintenance and growth of the organism?
3. What are the relationships of living organisms, and how are living things classified?
4. How do humans interact with other living things?

B. Cells, Genetics, and Evolution

1. What are cells? What are their component structures and their functions? How do they grow? What is the biochemical basis of life and of metabolism?
2. How are the characteristics of living things passed on through generations? How does heredity determine the development of individual organisms?
3. How has life changed and diversified through time? What processes and patterns characterize the evolution of life?

C. Ecosystems

1. What are ecosystems, and how do organisms interact in ecosystems?
2. How does energy flow within an ecosystem?
3. How do ecosystems change?
4. What are the responsibilities of humans toward ecosystems?

## frameworks

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### Florida's Framework Develops in Parallel with National Standards

*Science for All Students: the Florida pre K-12 Science Curriculum Framework*, carries a more recent date of 1 November 1993. With 89 pages, it is also a more modest effort than the 232 pages of its California predecessor. Seeing itself as developing in parallel with national standards, it is predicated on a vision of science education/learning, which shares the emphasis on joyfulness as the *California Framework* and is founded on nine underlying principles (see box). "If people don't know where they're going, how can the get there, and how do they know when they have arrived?" the *Florida Framework* asks.

Like the *California Framework*, the *Florida Framework* "recommends a shift from too much content treated superficially, to fewer topics, with more in-depth, thematic coverage." This shift is bolstered by a table on p. 37 comparing "traditional" with "recommended" practices in science instruction (adapted from Emmet L. Wright and Jack A. Perna, "Reaching for Excellence: A Template for Biology Instruction," *Science and Children*, **30**(2), 35 (1992)); a series of descriptors of learners, learning environments, and teachers; and descriptions of a series of recommended instructional strategies: cooperative learning, the learning cycle, concept mapping, predict-observe-explain, assessing and confronting misconceptions, community resources, questioning techniques, models, reflective thinking, laboratory investigation, educational technology, role playing and simulation, problem solving, and literature-history-storytelling.

The *Florida Framework* is characterized by eight knowledge strands; five recurring, embedded themes; seven processes of science; and eight habits of mind (see box). It is interesting to note that only three of the *California Framework* themes emerge in the same capacity in the *Florida Framework*, and that one of the California themes (energy) emerges as a Florida "knowledge strand." Pages 54-55 of the *Florida Framework* feature a matrix indexing the five themes for each of the eight strands for middle school. Neighboring pages emphasize the importance of interdisciplinary education and include a procedure for implementing an interdisciplinary unit at the high school level.

The *Florida Framework* goes into far more detail than its Californian counterpart in discussing assessment. The first page of the entire chapter allocated to this topic acknowledges that "*Meaningful* student assessment may well be the most difficult and frustrating aspect of a school science program. Science instruction, with its emphasis on hands-on activities and science processes, requires an appropriate assessment program. . . ." Continuing that "Good assessment is carefully-linked to instruction and is constructive, not punitive," this chapter goes on to describe and illustrate by example recommended assessment techniques.

### New York Framework Integrates Math, Science, and Technology

California has published frameworks for other academic disciplines as well as for science, and New York plans to do the same. In fact, New York appears to be the only state to combine its science framework with that for other disciplines — in its *Framework for Mathematics, Science and Technology*, most recently released in draft form on 5 March 1994. New York's frameworks are being developed in response to *A New Compact for Learning*, a 1991 document which "provides a rationale for systematic change and a vision for New York State's educational reform" and calls for more flexibility in attaining the New York State Regents Goals for Elementary, Middle, and Secondary School Students (printed on pp. 3-5 of the *Framework*). The

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**Underlying Principles supporting *Science For All Students: The Florida Pre K-12 Science Curriculum Framework***

1. All children can learn and are entitled to a meaningful education in science.

2. Science connects concepts and processes to everyday events.

3. Schools should provide a learning environment conducive to teaching and learning science.

4. Not all science learning takes place in schools. Both the natural and cultural environment greatly contribute to scientific literacy.

5. Cultural diversity promotes a positive, enriching, learning environment.

6. People learn science in different ways. Instructional programs and teaching strategies should accommodate diverse learning styles.

7. Excellence in science teaching and learning grows from a commitment shared by teachers, students, parents, and administrators.

8. Science learning promotes the evaluation of new ideas and alternative ways of knowing.

9. Science prepares people to make well-reasoned, thoughtful, and healthy decisions.

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frameworks are designed to enable the *Compact* to be implemented to achieve these goals. (The *Florida Framework* has a similar origin in response to *Blueprint 2000* — "Florida's plan for School Improvement and Accountability" — which "returns the control of the curriculum to the community.")

The New York *Framework for Mathematics, Science and Technology* is based on five General Principles for Learning and enunciates nine broad standards (see boxes), with each standard being elaborated by "performance indicators" for elementary, intermediate, and commencement levels. It also presents four "cornerstones" for achieving the Framework standards:

•Content and Curriculum (with less separation of the disciplines and fragmented factual learning);
•Instructional Models (with emphasis on constructivism, cooperative learning, integrated learning, problem solving, and inquiry);
•Restructured Learning Environment (with mutual respect and collaboration between students and teachers, who "need to change from being the fountain of knowledge to being facilitators of learning");
•Authentic Assessment ("move away from total reliance on paper-and-pencil tests to the use of some long-term assessment techniques such as term projects and research papers that require students to demonstrate the application of concepts in solving problems.").

The justification of the integration of standards for mathematics, science, and technology education in the New York *Framework* is the subject of an entire chapter which observes that "Mathematicians, scientists, and engineers are not the only citizens who require the skills, knowledge, and attitudes fostered by the study of mathematics, science and technology" and emphasizes the need "to avoid the encyclopedic approach to education, in which much is covered but little is learned."

New Jersey's efforts, also available only in draft form, have been limited to setting content standards. The "Final Draft 6/30/93" of *New Jersey Science Content Standards* that was distributed at the 1994 NSTA National Convention in Anaheim lists eight "body of knowledge" standards and six "nature and processes of science and its relationship to other areas" standards (see box). As in the case of the New York standards, "performance indicators" list what should result from student experiences in grades K-4, 5-8, and 9-12. The last two standards indicate New Jersey's agreement with New York in integrating the study of science with that of mathematics and technology. The *New Jersey Science Content Standards* adds that "Science should not be taught . . . devoid of its connectivity. . . ." and expresses concern that textbooks "thicken as material is added but rarely deleted."

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## General Principles for Learning in the New York *Framework for Mathematics, Science and Technology*

1. The learning process in grades K-12 must be integrated not only across areas of study within mathematics, science, and technology, but also across other academic disciplines.

2. Mathematics, science, and technology need to be presented in a context appropriate to the student's level of understanding.

3. The curricula in mathematics, science, and technology should be designed to achieve certain fundamental standards for all students which, in aggregate, comprise literacy in these areas.

4. Developing literacy in mathematics, science, and technology by all students is the highest priority. However, developing high levels of competency in mathematics, science, and technology is also necessary to stimulate and foster personal interests, civic responsibility, and career interests.

5. The assessment of student progress and achievement must be tied directly to standards and support their attainment.

## Characteristics of *Science For All Students: The Florida Pre K-12 Science Curriculum Framework*

Knowledge Strands

1. The Nature of Matter
2. Energy
3. Force and Motion
4. Processes That Shape the Earth
5. Earth and Space
6. Processes of Life
7. How Living Things Interact with the Environment
8. The Nature of Science

Themes

1. Patterns
2. Change and Stability
3. Systems and Interactions
4. Health and Well-Being
5. Science, Technology and Society

Processes of Science

1. Formulating Questions
2. Making Predictions
3. Planning Experiments
4. Making Observations
5. Classifying, Interpreting and Analyzing Data
6. Drawing Conclusions
7. Communicating

Habits of Mind

1. Honesty
2. Skepticism
3. Creativity
4. Curiosity
5. Tolerance
6. Open-mindedness
7. Sharing
8. Objectivity

# frameworks

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**How do the Frameworks view STS?**

The state science frameworks I have examined share the same commonalities I wrote about in my perspective on national science education reforms in our Spring 1994 issue: "depth of understanding instead of factual memorization... interdisciplinary and integrated learning ... constructivist and cooperative learning... alternative/ authentic assessment."

Where do the frameworks stand on STS? "We cannot expect our democratic society to make intelligent decisions about science, technology, and public policy unless its citizens are scientifically literate. . . .," states the *California Framework*. "Nature itself is morally and ethically neutral, but those who deal with science must make important moral and ethical choices. We have the responsibility of confronting students with some of the political and social issues that require an understanding of science." Echoing its mandate that science not be taught dogmatically, the *California Framework* makes it clear that "The teacher is ethically and professionally bound to confine science instruction to the facts, hypotheses, and theories of science." Yet it also stresses that ". . .controversy should not be a stranger in the classroom. The task of the science teacher is to guide students in the development of their abilities to approach controversial subjects cooly and rationally...." Backing this up is a section headed "Socially sensitive issues have a place in the science classroom," which suggests ways to deal with four such "socially sensitive issues": (resource) conservation, animal experimentation, evolution, and human reproduction ("Overpopulation is a biological issue with distinct human ramifications.").

Another section headed "Science, Technology, and Society" states that "Teaching with an Science, Technology, and Society (STS) approach is invariably interdisciplinary, with strong connections to history — social science, mathematics, literature, and the arts. Just as the thematic approach ... brings together disciplines within the sciences, an STS approach unites larger fields of study. Students who learn with peers and teachers about the inextricable connections among science, technology, and society have a very different experience from those who learn out of context." The analogy is made to teaching English without relating syntax to literature or history without relating events to "the cultures and characters that make them come alive." One of the accomplishments of the secondary school science program is to "Develop in students a strong sense of the interrelationship between science and technology and an understanding of the responsibility of scientists and scientifically literate individuals to both present and future societies." These ringing endorsements of STS are also backed up in the chapter directed at publishers. Five percent of the criteria for evaluating science teaching materials according to the *California Framework* is the presentation of science in its relationship to society.

By making Science, Technology, and Society one of its "recurring, embedded themes," the *Florida Framework* also endorses STS. This endorsement is also fleshed out by the statement that "A major goal . . . is to develop scientifically-literate and personally-concerned Floridians with a competency for rational thought and social involvement. Scientific literacy includes using science concepts, processes, and habits of mind in making everyday decisions and understanding how science contributes to our social fabric and economic development." Citing a phenomenon of particular concern to Florida, the case is made for integrating science with other subjects so that "students learn not just what a hurricane *is* but what it *does*."

By combining science and technology in the same document, the New York *Framework for Mathematics, Science and Technology* automatically combines two of the three components of STS. While the third (society) may not be so explicitly mentioned, Bill Peruzzi, Director of the New York Science, Technology, and Society Education Project (NYSTEP), has praised the New York *Framework* for being consistent with NYSTEP's mission ("to encourage teaching and learning that lead to responsible citizenship").

This survey of state science education frameworks has by no means even been intended to be exhaustive. In fact, the lead story in the October/November 1992 issue of *NSTA Reports!* states that, according to a report from the Council of Chief State School Officers (CCSSO), "Thirty states have science frameworks or guides... and 15 states are in the process of developing one." I hope that many *Newsletter* readers from states not represented here will be quick to send me reports about the science education frameworks in their states, with particular attention to the role of STS. Such reports will be shared with our entire readership in the Winter 1995 issue.

**How to get copies of published frameworks**

*Science Framework for California Public Schools, Kindergarten Through Grade Twelve*, Bureau of Publications, Sales Unit, California Department of Education, P.O. Box 271, Sacramento, CA 95802-0271, (916)-445-1260. ISBN 0-8011-8070-5. xii + 220 pp. $6.50.

*Science for All Students: the Florida pre K-12 Science Curriculum Framework*, Office of Science Education Improvement, Florida Department of Education, 325 West Gaines Street, 344 Florida Education Center, Tallahassee, FL 32399-0400, (904)-922-4207. 89 pp.